WHOLISTIC ENGINEERING:

Applied to Living Building Water Systems

2007 American Rainwater Catchment Systems Association Conference

Hawai'i Volcanoes National Park, Big Island of Hawaii

August 14-17, 2007

2020 ENGINEERING, Inc.

Bellingham, WA

WHOLISTIC ENGINEERING

- 2020 ENGINEERING's approach for problem solving

WHOLISTIC ENGINEERING:

Definition

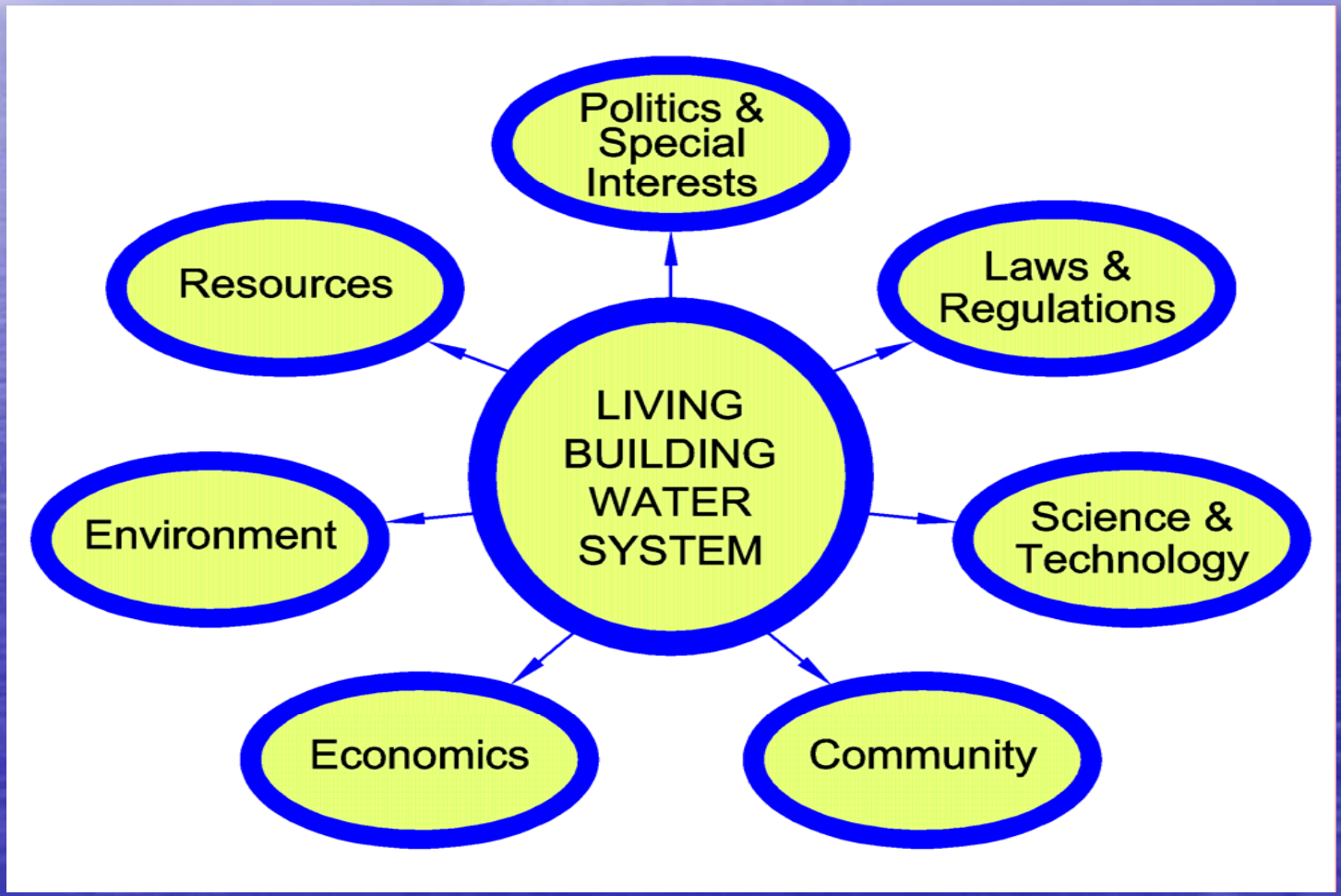
Wholistic Engineering is a management approach which includes the comprehensive inclusion of all issues and possible conditions related to the primary task or mission

Wholistic: *relating to a complete and total system or organization of parts fitting or working together as one. A system, which may also exist within a whole system, includes a group of units or method of procedure so combined as to form a functioning whole and operating in unison: an organized whole*.

Engineering*: a science by which the resources and properties of matter and sources of energy are made useful to humankind in systems, structures, machines, and products.*

WHOLISTIC ENGINEERING

It's all about relationships…



WHOLISTIC ENGINEERING

Design Approach

- Whole System Design
  - "Site" Relationships
- Integrated Design
  - "Design" Relationships
- Sustainable Design
  - Materials & Resources

WHOLISTIC ENGINEERING

- Our criteria for evaluating possible solutions:

1. Economical (short-term and long-term costs)
2. Environmentally Friendly (ecologically compatible)
3. Simple (easy to build and operate)

WHOLISTIC ENGINEERING

leads to…

- Ecological / Ecosystem Based Solutions

  ✓ Mimic Natural Systems

  ✓ “Eliminate the Problem/Root Cause”
  vs.
  “Treat the Problem/Symptom”

WHOLISTIC ENGINEERING

Introduction

Why talk about water?

It's all about the people…

As the world's population continues to grow, now at a rate of about 10,000 per hour, the same finite water resources are going to have to go farther and be treated wisely. In order to meet our future water needs, simple solutions are needed that are both economical and environmentally friendly.

Water Resources
Definitions

- **Potable Water** (Drinking Water)
  - **Piped to Site** (Municipal Water)
  - **Trucked to Store** (Bottled Water)
  - **Extracted from Ground** (Well Water)
  - **Collected On-site** (Rainwater)

Requires separate piping system for each type of water quality

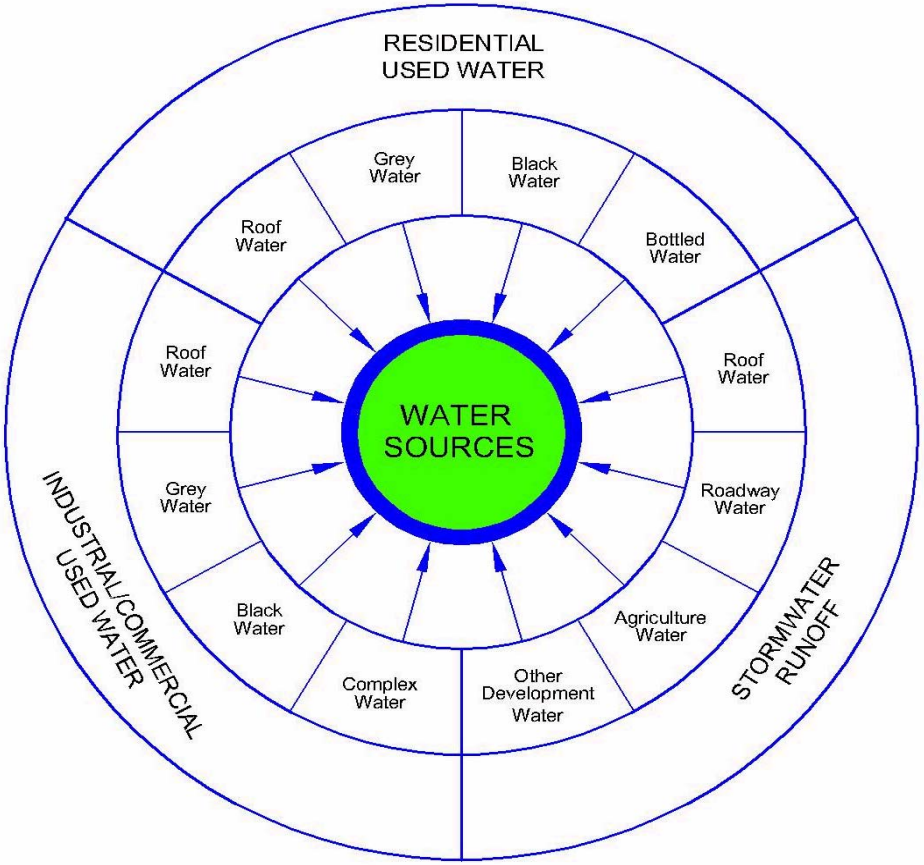
- **Stormwater** (General rainwater run-off from sites)
- **Rainwater** ("Clean" roof run-off)
- **"Waste"water** (An out-dated term; all types of water are considered resources)
  - **Blackwater** (Flush toilets and urinals)
  - **Brownwater** (Toilet water with feces without urine)
  - **Yellow Water** (Urine - separated at source before mixing with feces)
  - **Greywater**
    - **Light Grey** (Bathroom sink, shower, bathtub, laundry)
    - **Dark Grey** (Kitchen sink)
  - **Combined Water** (Blackwater & greywater)
- **Reclaimed Water** (Treated "waster"water - Water Reuse)

WHOLISTIC ENGINEERING

Water Resource Management

Water Sources

- All types of water are recognized as water sources
- Eliminate the term ”wastewater”



HUMAN IMPACTED WATER SOURCES

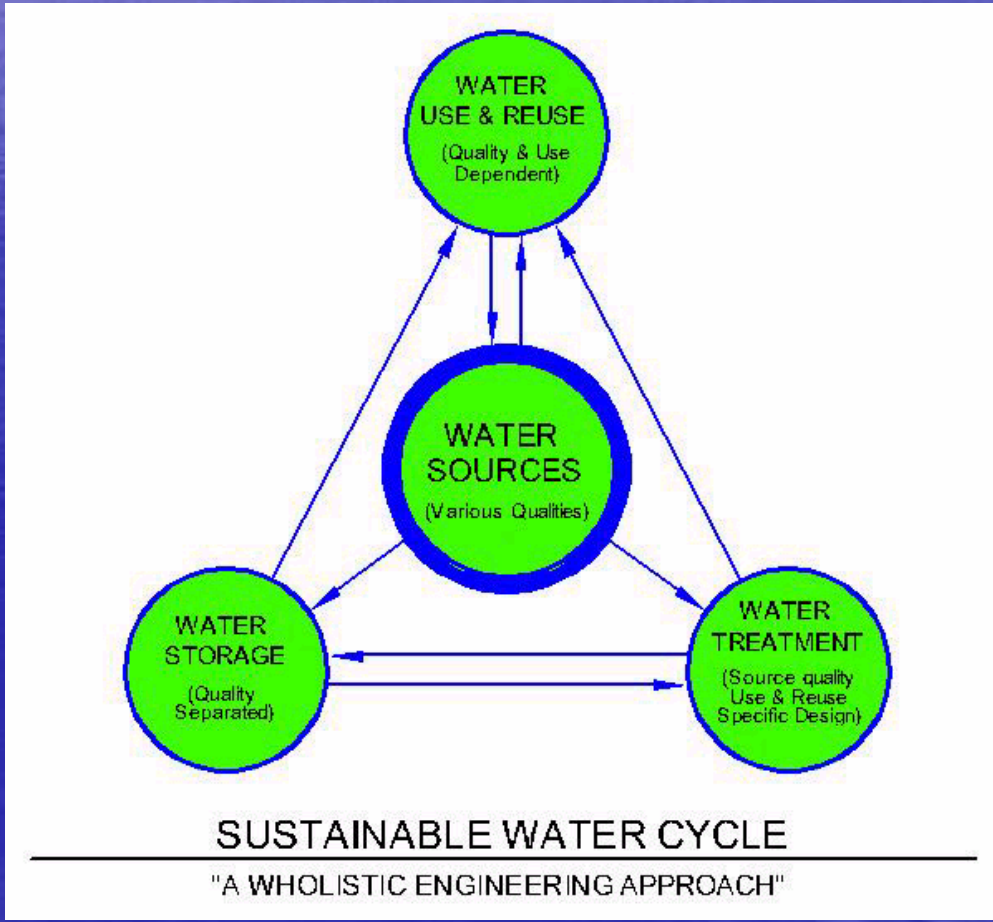
(Of a Recycling/Reuse System)

WHOLISTIC ENGINEERING

Water Resource Management

- Separated water sources are handled individually for each specific use or re-use

Water Sources - Uses and Re-Uses



Rainwater Harvesting

Why is there more talk in the U.S. and Canada about Rainwater Harvesting?

- **Two Newer Types of Projects**
  - Sustainable “Green” Building
  - Low Impact Development (LID)

Low Impact Development

- L.I.D. Site Design Techniques
  - Geometrics & Layout (Build Less; i.e., Narrow Streets)
  - Porous Pavements (Permeable Surfaces)
  - Bioretention (Raingardens)
  - Soil Amendments (Compost Amended Soils)
  - Low Impact Foundations (Little or No Excavation)
  - Green Roofs
  - Rainwater Harvesting

Rainwater Harvesting

- LID - Stormwater Management Technique
  - Options for potable and non-potable water uses
  - Non-potable uses include toilet flush, laundry, and irrigation

Islandwood – Cisterns for irrigation of organic gardens

LEED:
Leadership in Energy & Environmental Design

A leading-edge rating system for designing, constructing, and certifying the world's greenest buildings.

Green Building

LEED Scoring - 69 points total**:**

1. Sustainable Sites: 14 points
2. Water Efficiency: 5 points
3. Energy and Atmosphere: 17 points
4. Materials and Resources: 13 points
5. Indoor Environmental Quality: 15 points

– Innovation: 4 points

– LEED Accredited Professional: 1 point

2020 ENGINEERING

U.S. GREEN BUILDING COUNCIL LEED LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Green Building

LEED Rating:

- **Platinum** 52-69 points
- **Gold** 39-51 points
- **Silver** 33-38 points
- **Certified** 26-32 points

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U.S. GREEN BUILDING COUNCIL

LEED™

LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Green Building
Rainwater Harvesting

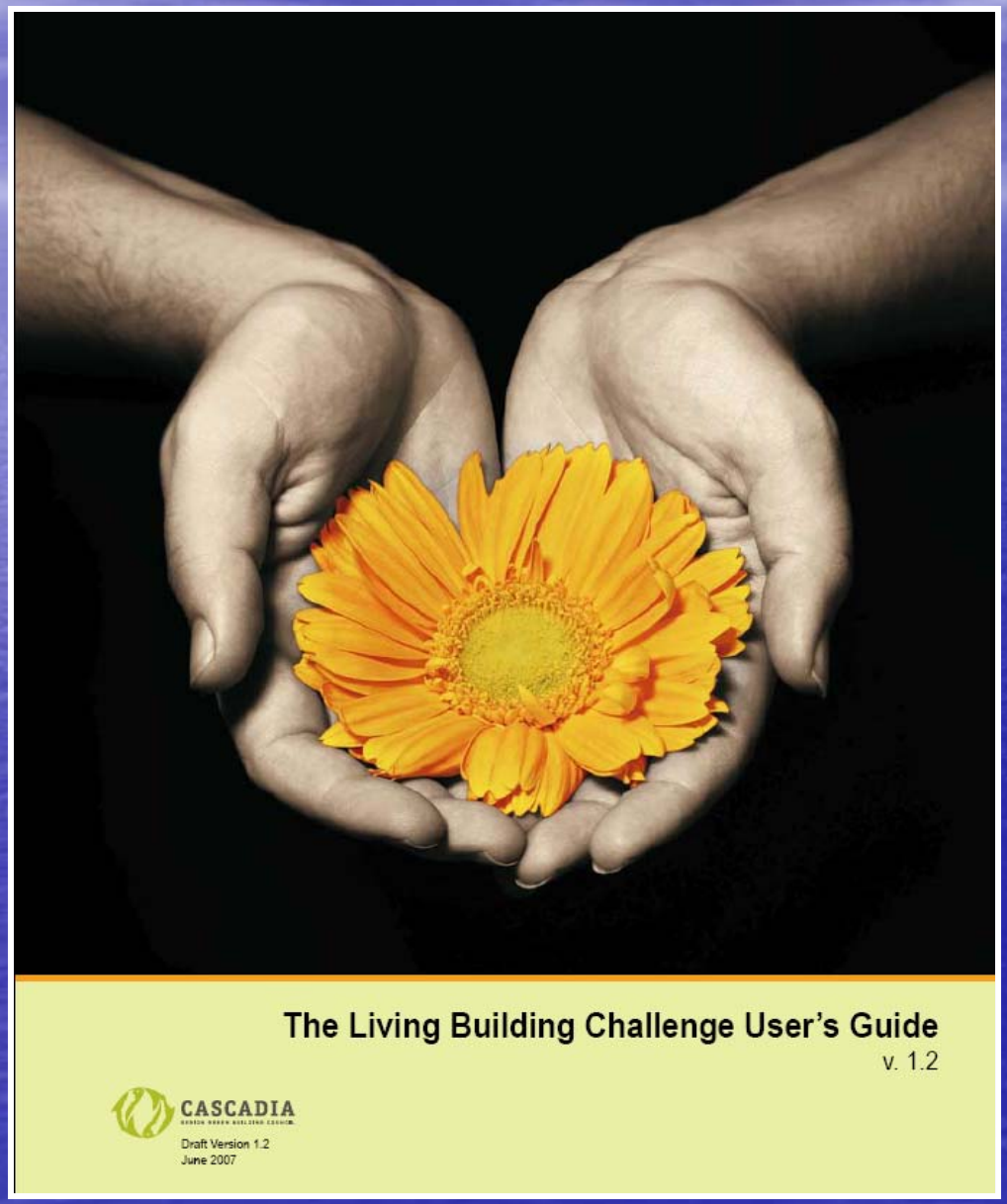
Water LEED Categories

- Water Efficiency
  - 2. Innovative Wastewater Technologies (1)
  - 3. Water Use Reduction (2)

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

The Living Building

The Living Building



The Living Building

The Living Building

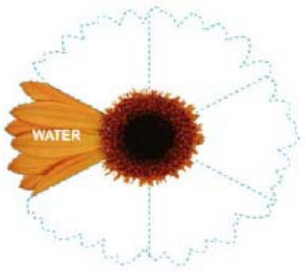
Summary of Prerequisites

Number	Category	Prerequisite
One	Site Design	Responsible Site Selection
Two	Site Design	Limits to Growth
Three	Site Design	Habitat Exchange
Four	Energy	Net Zero Energy
Five	Materials	Materials Red List
Six	Materials	Carbon Footprint
Seven	Materials	Responsible Industry
Eight	Materials	Appropriate Materials Radius
Nine	Materials	Construction Waste
Ten	Water	Net Zero Water
Eleven	Water	Sustainable Water Discharge
Twelve	Indoor Environmental Quality	Civilized Work
Thirteen	Indoor Environmental Quality	Source Control
Fourteen	Indoor Environmental Quality	Ventilation
Fifteen	Beauty & Inspiration	Design for Spirit
Sixteen	Beauty & Inspiration	Inspiration and Education

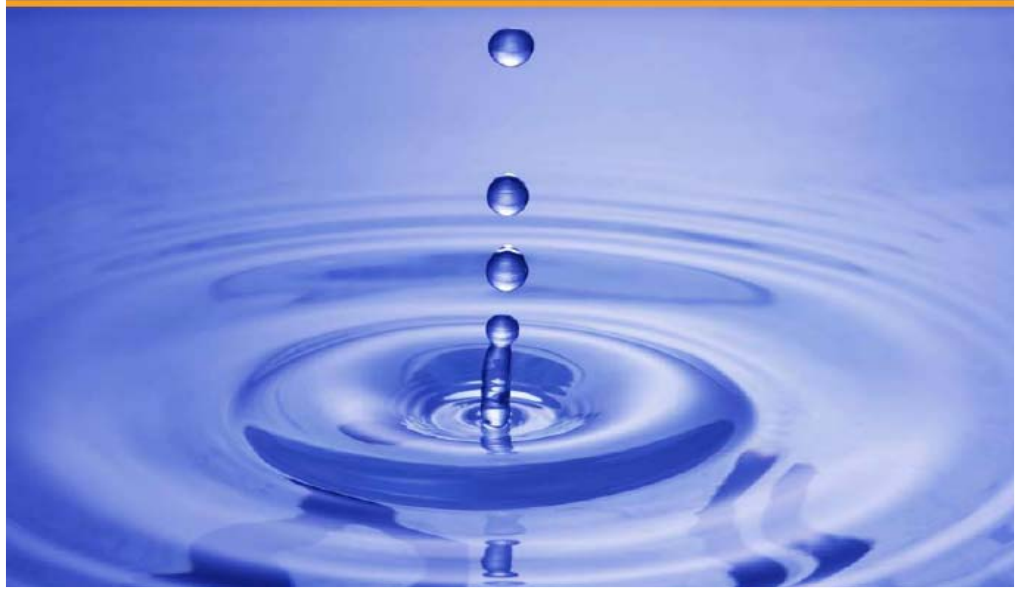
The Living Building

- Net Zero Energy
- Net Zero Water

The Living Building



Water Module



The Living Building

Water Module

WATER MODULE

A Living Building is water independent.

Prerequisite Ten – Net Zero Water

Summary

100 percent of occupants' water use must come from captured precipitation[1] or reused water that is appropriately purified without the use of chemicals[2].

Prerequisite Eleven – Sustainable Water Discharge

Summary

100 percent of storm water and building water discharge must be handled on-site.

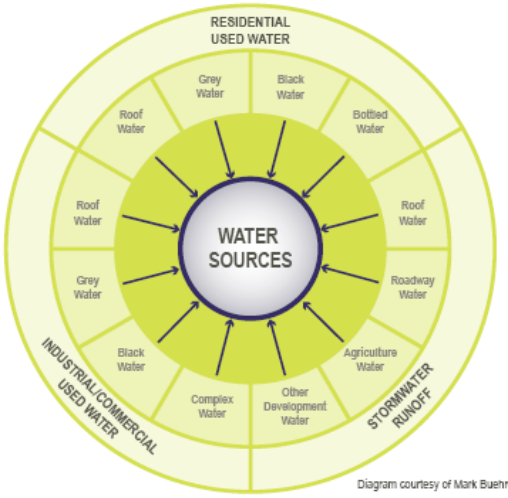


Diagram courtesy of Mark Buehrer

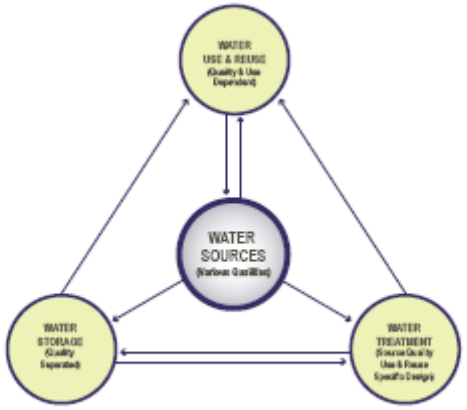


Diagram courtesy of Mark Buehrer

Living Building Challenge

Category: Water

Sustainable Design Principles

1) **Mimic Natural Systems**

   Example - stormwater: maintain/restore natural hydrology (i.e., raingardens and porous pavements)

2) **Do not "pee" in the drinking water**

   * Use reclaimed water or rainwater to convey wastes (toilets), or,
   * Do not use water to convey wastes (i.e., use composting toilets)

3) **Reuse/Recycle all water sources impacted by human activities**

   Examples - greywater: source separate (i.e., irrigation)
   reclaimed water: dual piping (i.e., toilet flush)

4) **Implement water conserving fixtures throughout**

5) **Use highly water efficient systems**

Living Building Challenge

Water Systems

- Features “On-Site” Techniques

Decentralized Approach
(Small Scale Systems)

vs.

Centralized Approach
(Large Scale “Municipal” System)

ecological sanitation

commissioned by

gtz

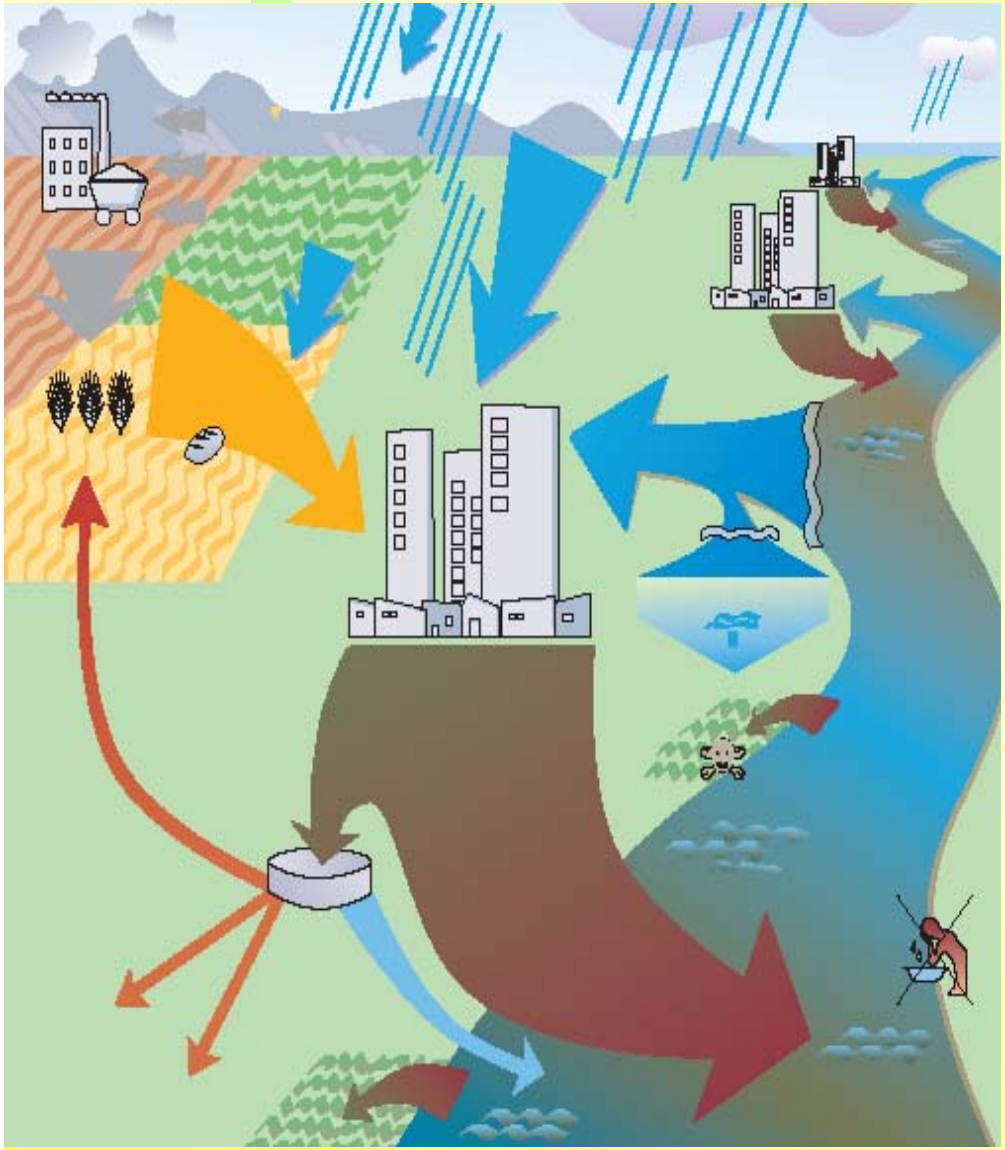
Federal Ministry
for Economic Cooperation
and Development

world water and sanitation crisis

- Increasing scarcity and degrading quality of freshwater
- 1.1 billion people around the world have no access to safe drinking water
- 2.4 billion people have inadequate sanitation and/or no means of wastewater disposal
- Expected growth of the global population by another 2 billion people within the next 25 years needing sanitation
- 90 % of wastewater worldwide is either poorly treated or not treated at all at discharge
- 80 % of all diseases and 25 % of all deaths in developing countries can be attributed to polluted water (WHO)

ecosan principles

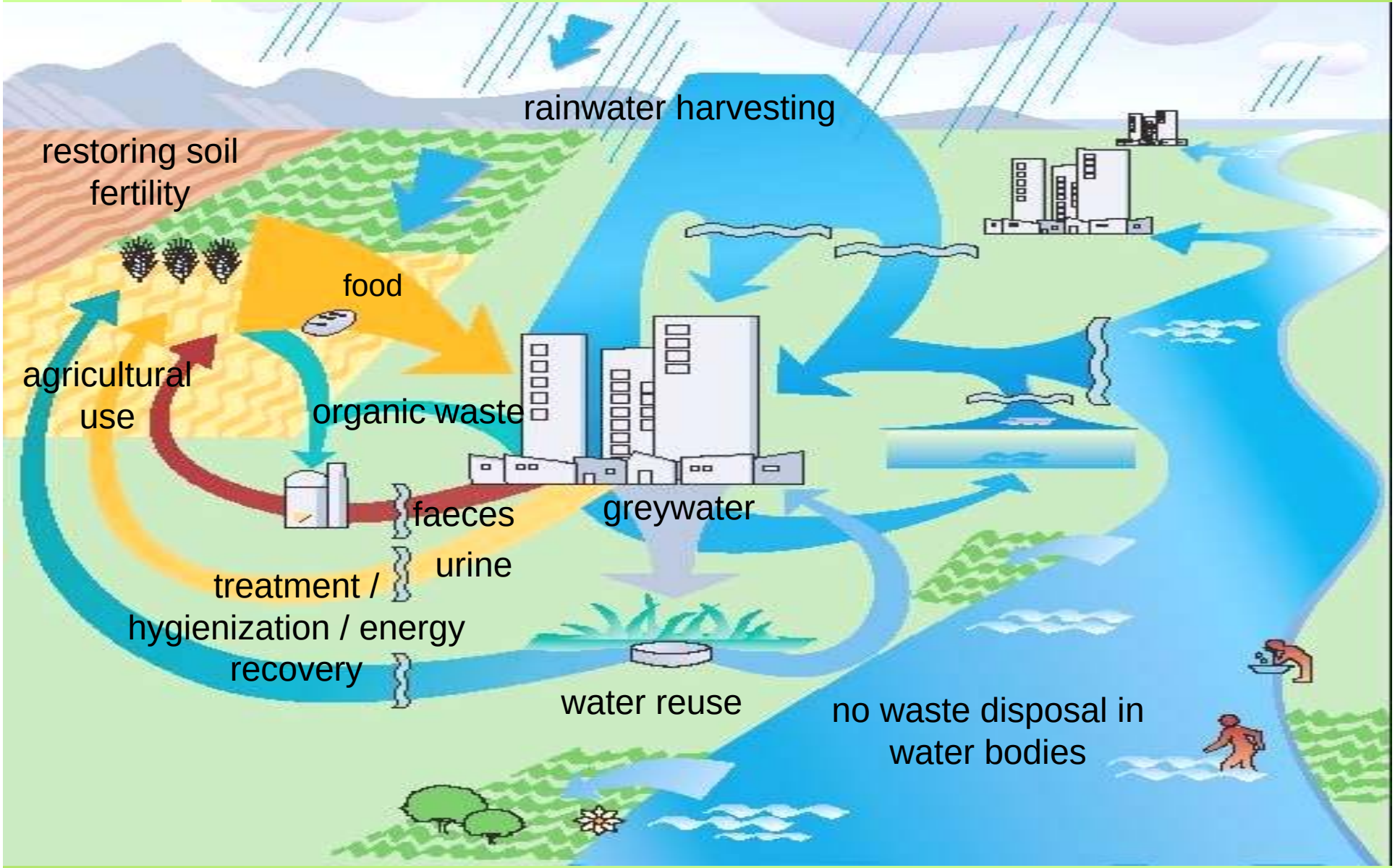
shortcomings of conventional water carriage sanitation



- Unsatisfactory purification or uncontrolled discharge of more than 90 % of wastewater worldwide
  - ➔ Severe water pollution, unbearable health risks
- Consumption of precious water for transport of waste
- High investment, energy, operating and maintenance costs
- Frequent subsidization of prosperous areas and neglect of poorer settlements
- Loss of valuable nutrients and trace elements contained in excrements due to discharge into waters
- Problems with contaminated sewage sludge in combined, central systems
- **Linear end-of-pipe technology**

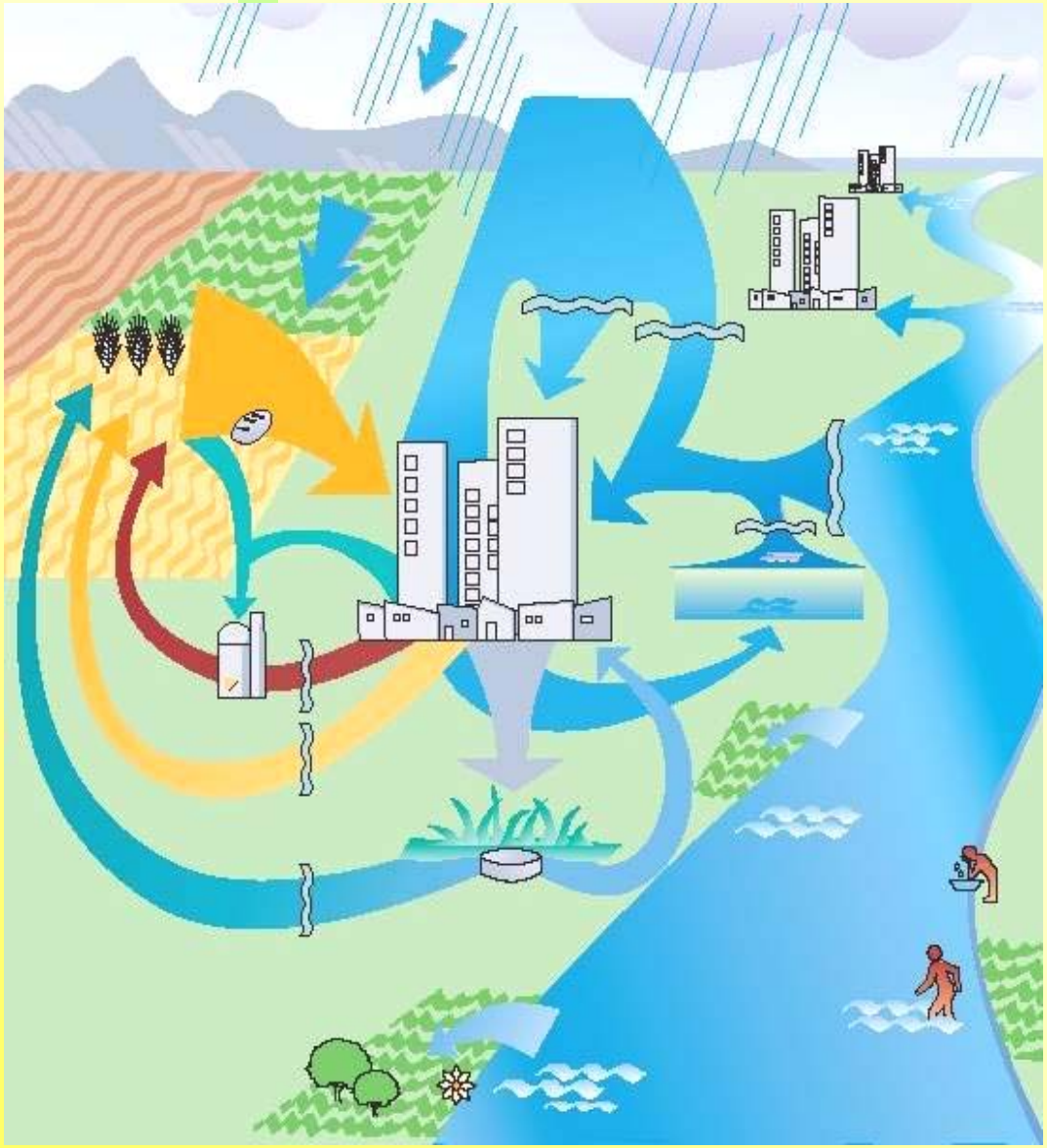
ecosan principles

closing the loop between sanitation and agriculture



ecosan principles

ecological sanitation - a new approach



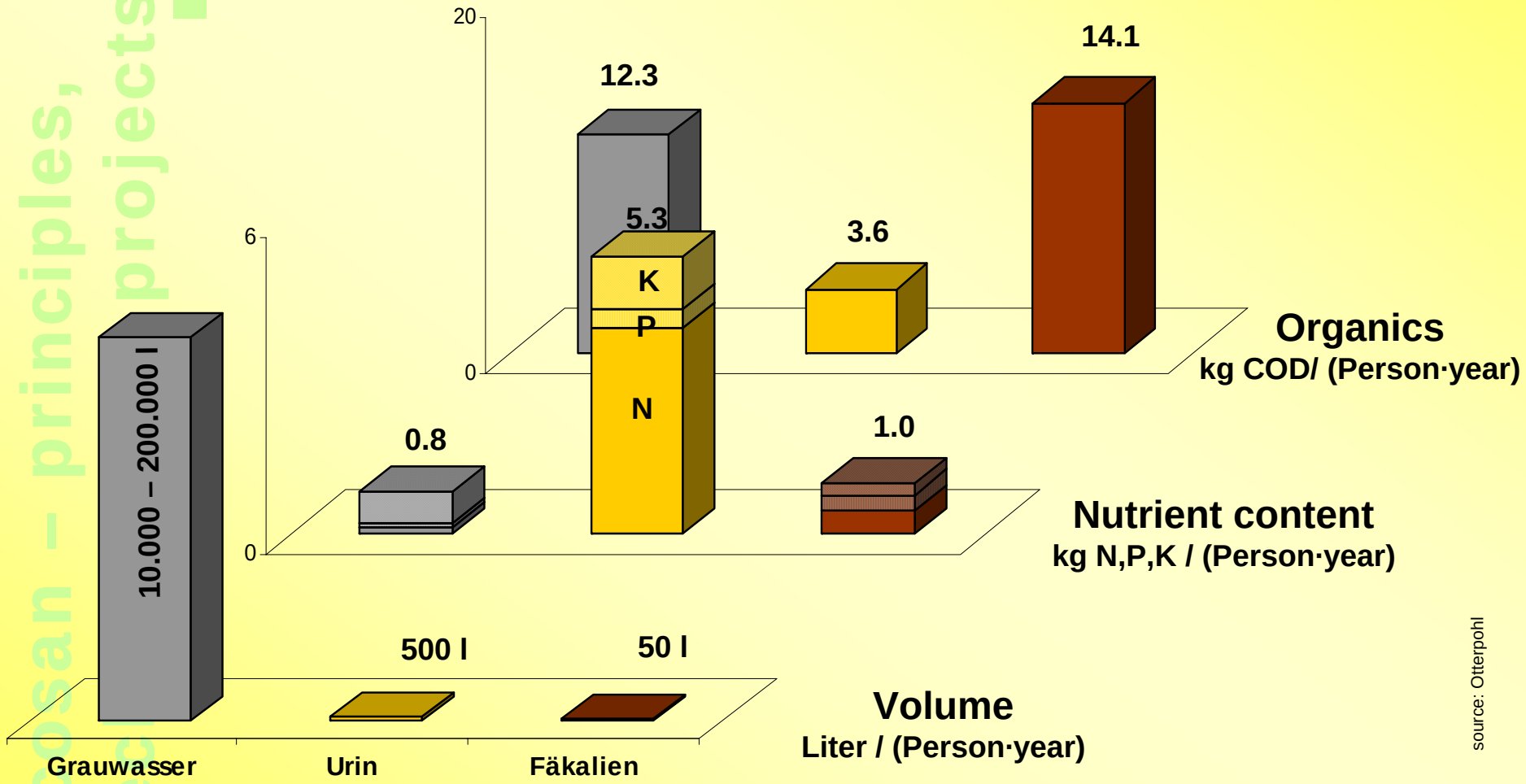
- Improvement of health by minimizing the introduction of pathogens from human excrements into the water cycle
- Promotion of safe recovery and use of nutrients, organics, trace elements, water and energy
- Preservation of soil fertility and improvment of agricultural productivity
- Conservation of resources
- Preference for modular, decentralised systems for more appropriate, cost-efficient solutions
- Promotion of a holistic, interdisciplinary approach
- **Material flow cycle instead of disposal**

cco-sanitation concepts and strategies

eco-sanitation…

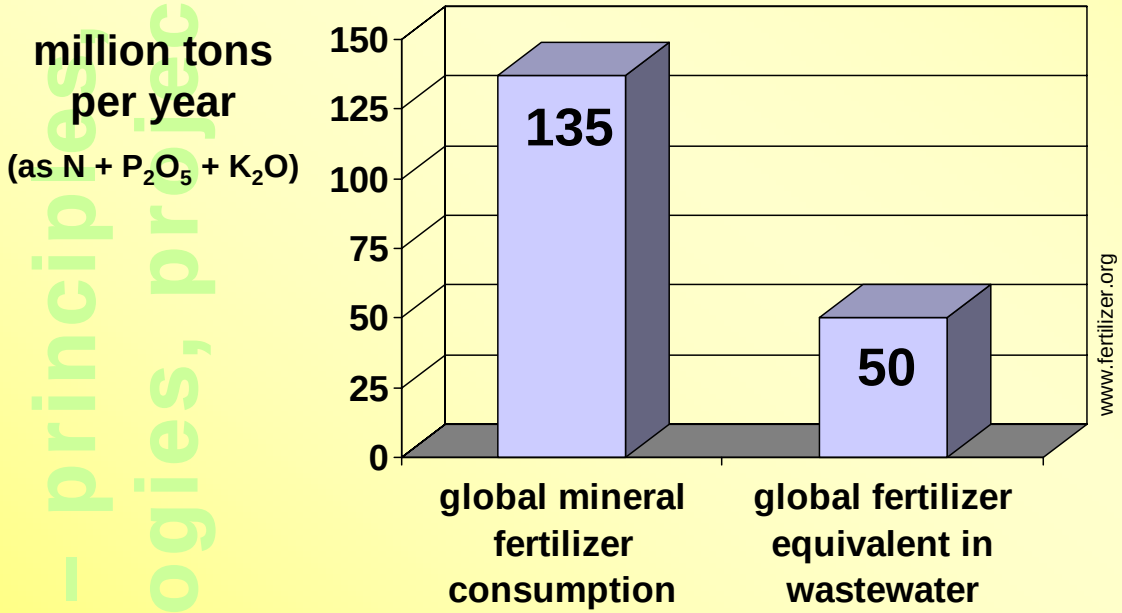
- … applies the basic natural principal of closing the loop by using modern and safe sanitation and reuse technologies
- …considers human excreta and wastewater not as wastes but as natural resources

composition of household wastewater



source: Otterpohl

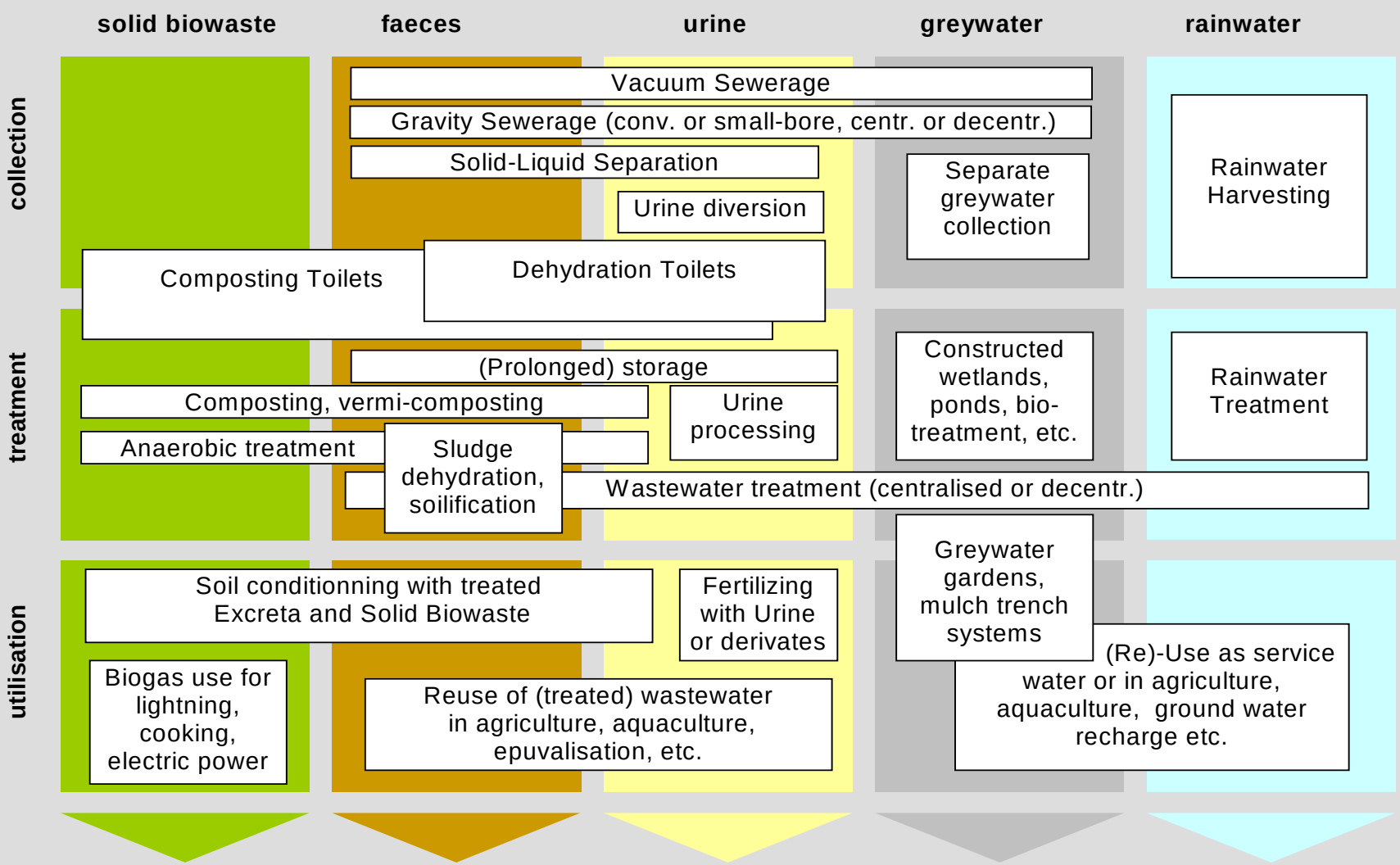
wastewater and excreta are a valuable resource



www.fertilizer.org

- farmers around the world yearly require 135 Mio tons of mineral fertiliser for their crops, while at the same time conventional sanitation dumps 50 Mio tons of fertiliser equivalents from so called wastewater flows into our water bodies - nutrients with a market value of around **$15 Billion US dollars**.

technical data sheets for ecosan components overview



examples of urine diverting toilets

Wost-Man, Sweden

▲

dry/wet: faeces without, urine with flush

Roediger, Germany

▲

dry/wet: faeces with, urine without flush

Dubletten, Sweden

▲

wet: faeces & urine with flush

ecosan technologies

waterless urinals

Mon Museum, Sweden

Lambertsmühle, Germany

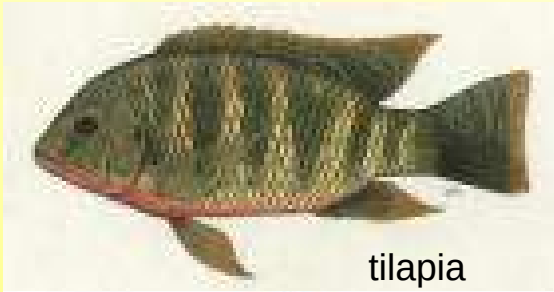
Ernst

Keramag

Urimat

aquaculture

- wastewater treatment by aquatic plants and fish with nutrient recyling by human consumption
- offers high quality protein at low cost
- predominantly in Asian countries
- fish production of 1-6 tons/ha·year) achieved


tilapia


carp


duckweed

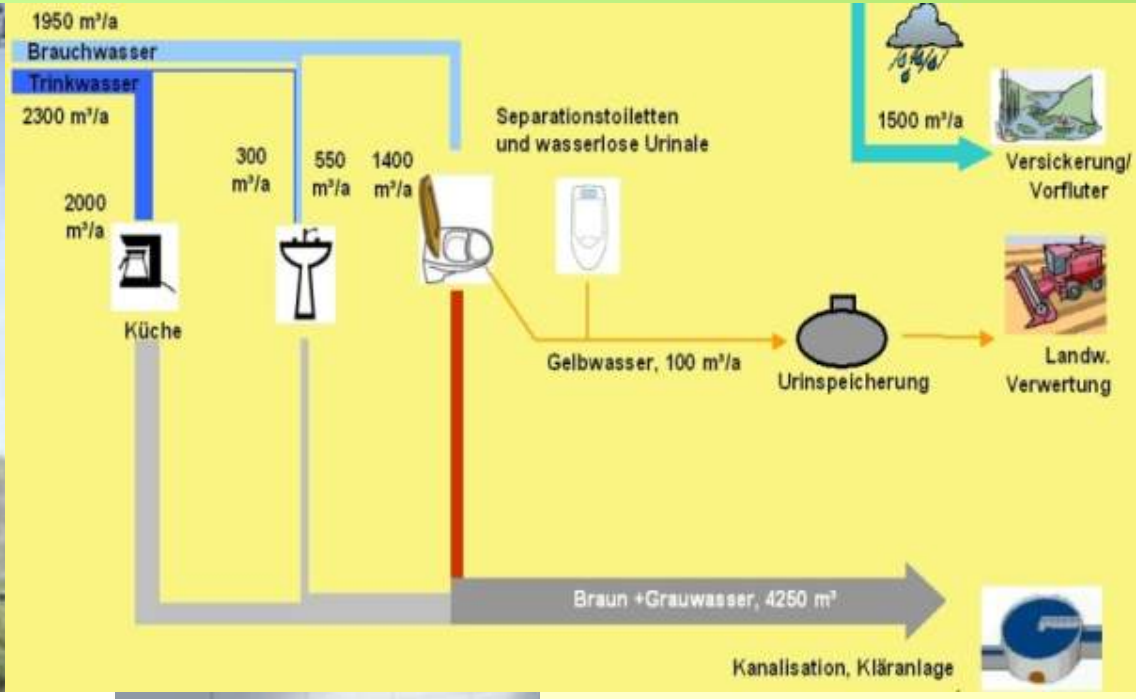
ecosan technologies

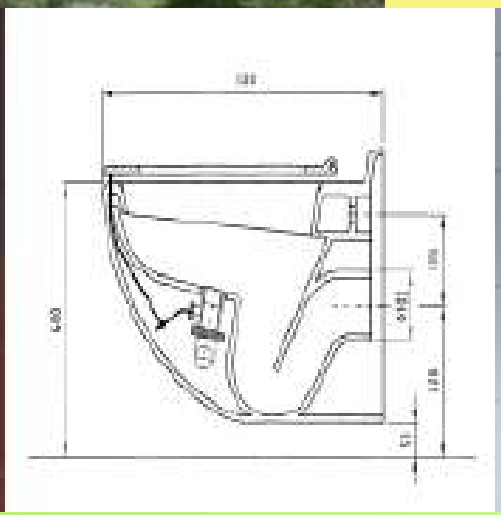
“epuvalisation“ - hydroponics

nutrient recycling (Senegal)

ecosan projects

main building of GTZ headquarter, Germany





ecosan concept: separation, processing and agricultural reuse of urine (implementation 2004/2005)

urine diversion toilets and waterless urinals

Rainwater Harvesting fits well to Ecosan

Ecosan can diminish the freshwater demand strongly resulting in longer lasting tank reserves

The Mizoram government took up rainwater harvesting under its public water supply programmes in 1986. As a policy, it is replacing all thatch roofs with galvanised sheet roofs to promote rooftop water harvesting.

from CSE India
see www.rainwaterharvesting.org

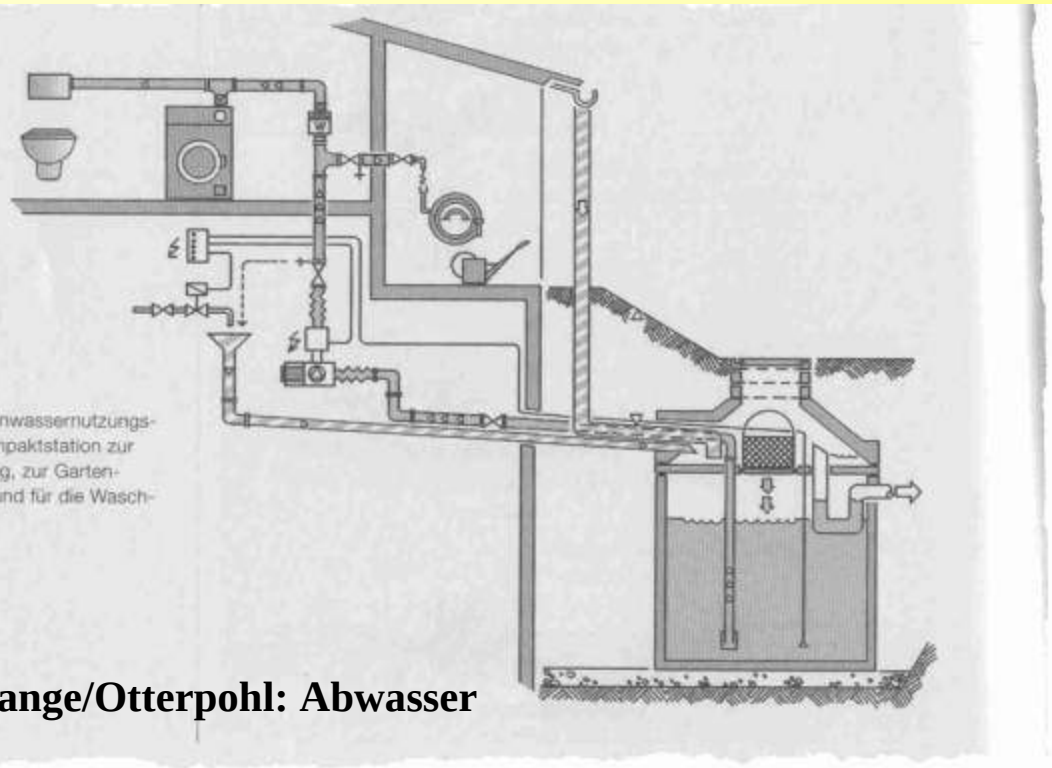


Abb. 51:
Moderne Regenwassernutzungsanlage mit Kompaktstation zur Toilettenspülung, zur Gartenbewässerung und für die Waschmaschine

from Lange/Otterpohl: Abwasser

Storage tanks

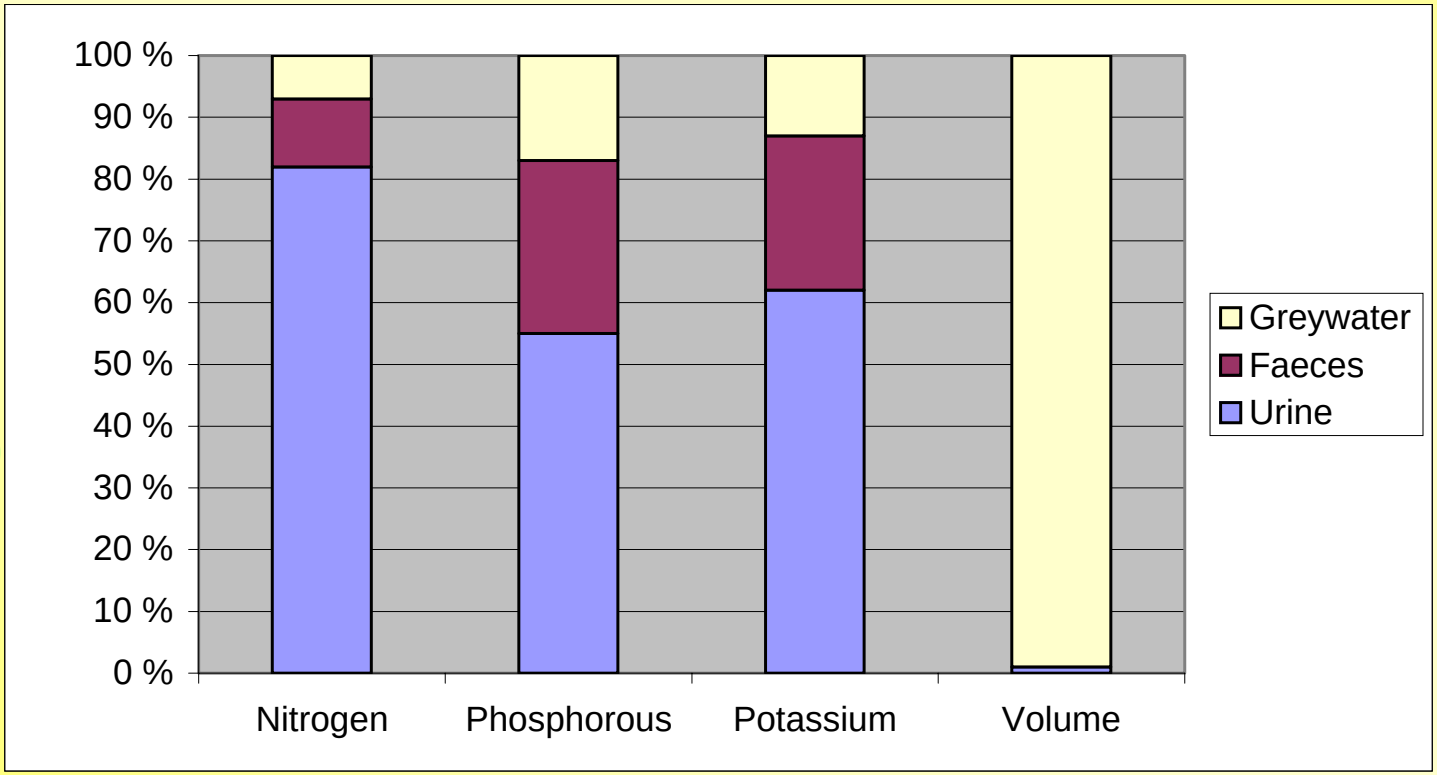
in the construction phase

in use

Source separation of wastewater

(Alsen and Jenssen 2005)

Nutrients and volume of domestic wastewater fractions



(Jönsson et al., 2000).

Urine divertion and dry composting of fecal matter at Tingvall conference center Sweden

Photos: P.D. Jenssen

Urine divertion and dry composting of fecal matter at Tingvall conference center Sweden

Photo: P.D. Jenssen

Project Examples

- Bayview Corner - Public Restroom Building

Living Building

Example – Integrated Design

- Bayview Corner Public Restroom Building – Rainwater Collection for toilet flushing
- Combines other strategies to be essentially “off the water grid”

Water Efficiency

Ecological “Waste”water Treatment and Re-Use

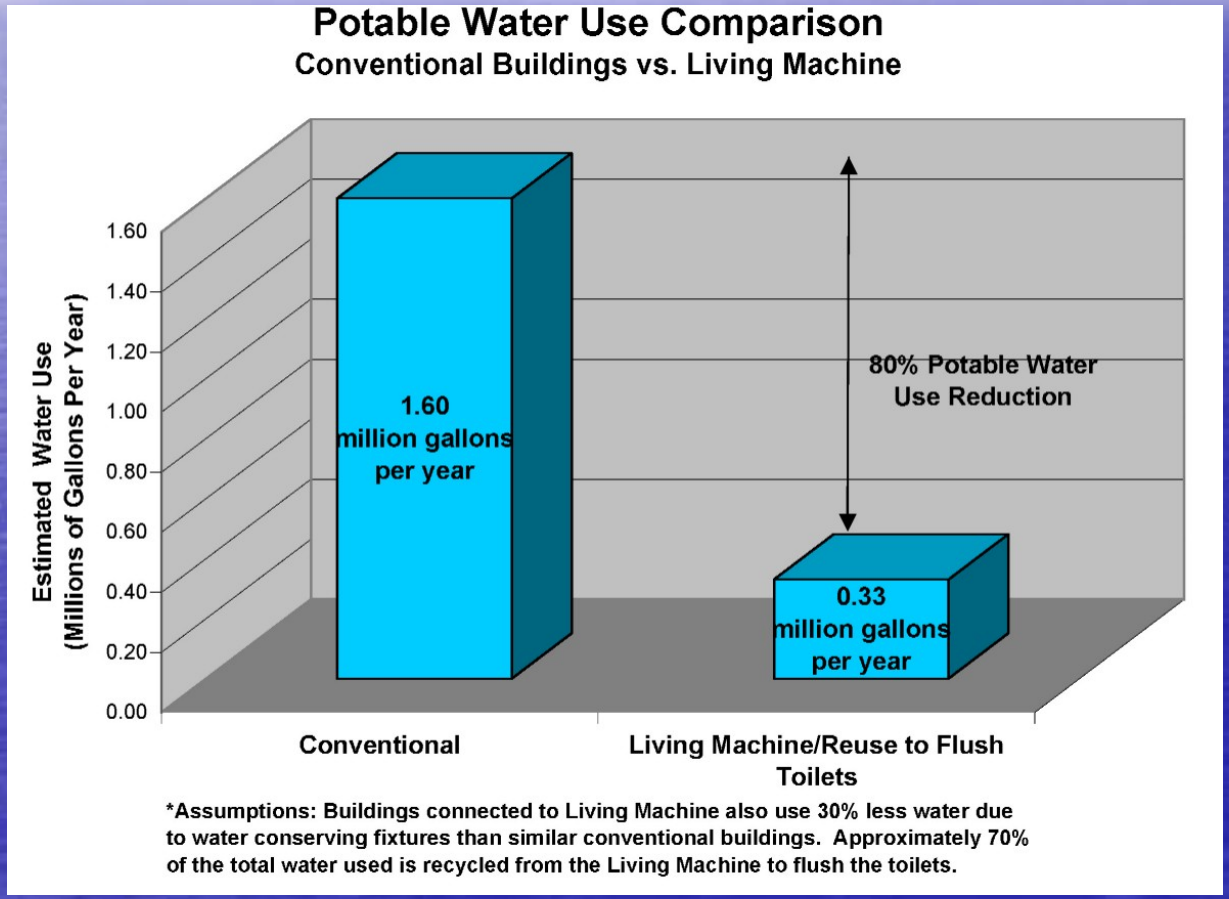
- **Living Machine:**
  - **An ecological wastewater treatment system**
  - **Uses of reclaimed water**
  - **Educational**

Missouri Discovery Center
Kansas City, Miissouri

Islandwood… An Environmental Learning Center
Bainbridge Island, Washington

Water Use Efficiency

Ecological “Waste”water Treatment and Re-Use



Islandwood… LEED: “GOLD”

Living Building
A Sustainable Water Resource Management Plan

Pleasant Harbor - Hood Canal

Living Building

Sustainable Water Resource Management

Pleasant Harbor – Proposed Re-Development

Living Building
Sustainable Water Resource Management

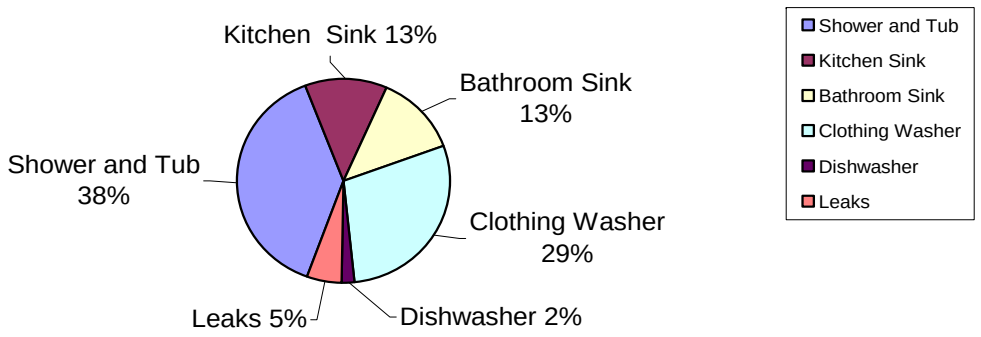
TOTAL ESTIMATED POTABLE WATER USE WITH HIGH-EFFICIENCY CONSERVATION FIXTURES

Usage	Flow Rate	Flow Units	Usage	Usage Units	Total Use Per Person		%
Shower and Tub	1.50	gpm	8.2	min/day	12.30	gal/day	38%
Kitchen Sink	0.50	gpm	8.1	min/day	4.05	gal/day	13%
Bathroom Sink	0.50	gpm	8.1	min/day	4.05	gal/day	13%
Clothing Washer	25.00	gal/load	0.37	loads/day	9.25	gal/day	29%
Dishwasher	6.00	gal/load	0.1	loads/day	0.60	gal/day	2%
Leaks					1.70	gal/day	5%
				Total Consumption Per Person:	**32**	**gal/day**	**100%**

ERU - Total Consumption Per Residence (2.2 people per unit):	**70**	**gal/day**

Note:
Usage figures obtained from: American Water Works Association (AWWA) Research Foundation, *Residential End Uses of Water study*, Mayer and DeOreo, et al., 1999

DAILY INDOOR POTABLE WATER DEMAND ESTIMATE



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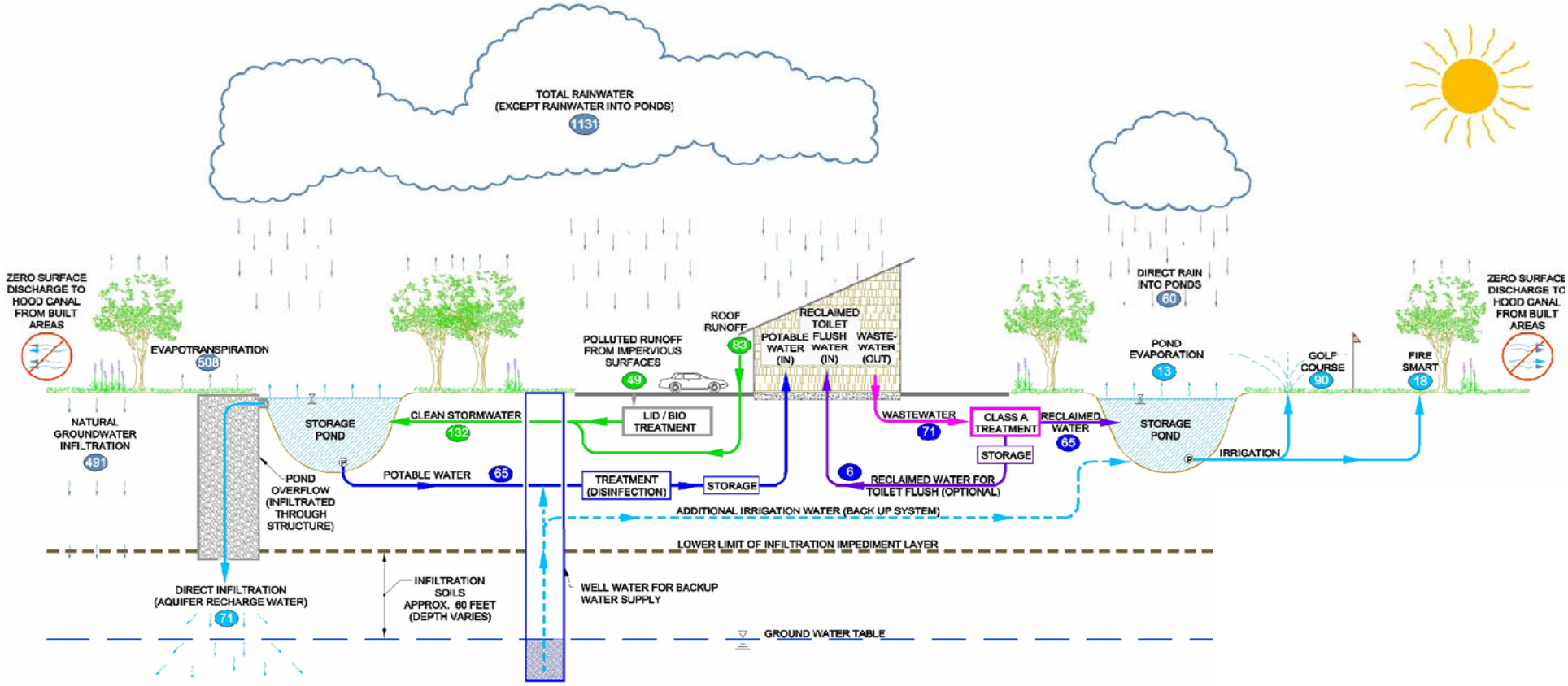
Sustainable Water Resource Management

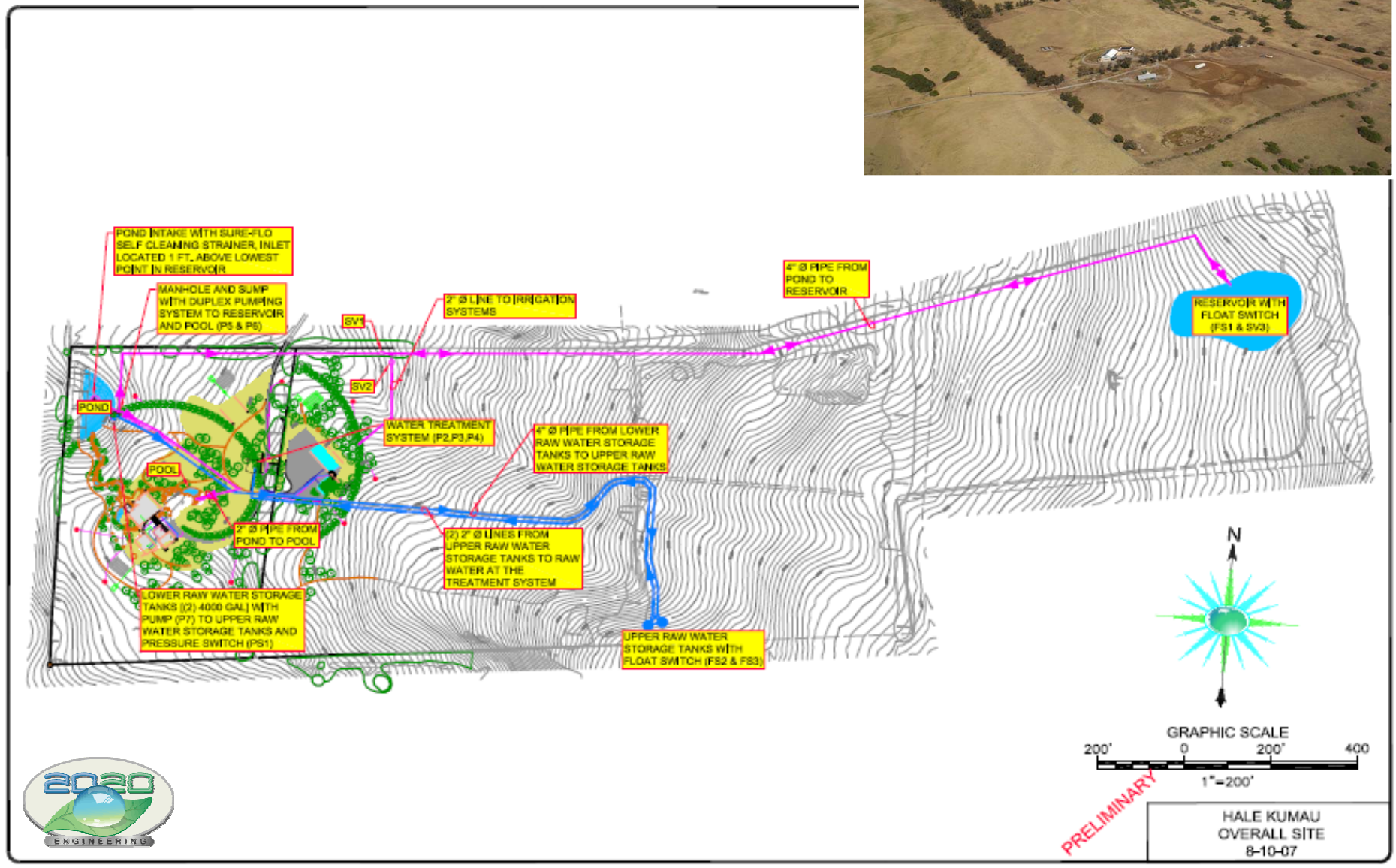


"Closed-Loop" Water Cycle

Concept Flow Diagram

Living Building

Sustainable Water Resource Management



Living Building

Sustainable Water Resource Management

Hale Kumau – Big Island Hawaii

Living Building

Sustainable Water Resource Management

Hale Kumau – Big Island Hawaii

Living Building Challenge

Codes & Regulations

In Order To Provide Sustainable Water Systems...

- There needs to be a reasonable balance between Human Health Risks, Environmental Issues and Economics

WHOLISTIC ENGINEERING:

Applied to Living Building Water Systems

SUMMARY